International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 9, Issue 3, Jun 2019, 1493-1500

CORROSION STUDY OF SHORT CARBON FIBER REINFORCED ALUMINIUM METAL MATRIX COMPOSITES

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ABSTRACT

The corrosion behaviour of the composites under the different condition that the material is probably going to experience is one vital thought while picking up a suitable material for a specific engineering application. The corrosion behaviour of metal–matrix composite is determined by several factors such as the composition of the alloy, the matrix microstructure, the reinforcement and the technique adopted in preparing the composite. The corrosion behaviour of the casted aluminium alloy and the developed composites were studied for basic and acidic environments under corrosion by weight loss method. It was observed from the corrosion test in different corrosive media that, the corrosion resistance of the prepared MMCs is not much affected due to the addition of carbon fiber into the matrix.

***KEYWORDS**: Carbon Fiber, MMC & Corrosion*

Received: Apr 23, 2019; **Accepted**: May 13, 2019; **Published**: Jun 08, 2019; **Paper Id.**: IJMPERDJUN2019157

Original Article

INTRODUCTION

Corrosion is a slow, progressive or rapid deterioration of metal properties such as its appearances, its surface aspects, or its mechanical properties under the influences of the surrounding environments like atmosphere, water, sea water, various solutions, organic environments, etc. Composite materials should have good properties like strength, wear resistance and also better corrosive resistance property. A particulate acts as a barrier for the crack and improvement of corrosion pits and furthermore adjusts the microstructure of the matrix material and hence lessens the rate of erosion. The better resistance of the MMCs is presumably because of reinforcement network interfering with the reaction between the acid and the metallic matrix.

EXPERIMENTAL DETAILS

Specimen Preparation

The specimens in the form of small cylindrical discs were obtained from the bar castings. Discs having diameter 20 mm and thickness 20 mm were used for the study. Using an abrasive cutting wheel, the material was cut into 20 × 20 mm pieces as per ASTM standards. Using 240, 320, 400 and 600 grit sized SiC paper the samples were then ground and polished according to standard metallographic techniques and dipped in acetone and dried. Electronic balance and Vernier gauze are used to weigh (up to the fourth decimal place) the samples and note the dimensions respectively. Figure 1 shows the specimen used for corrosion study.

Figure 1: Specimen for Corrosion Study

Solution Preparation

The sodium chloride solution was prepared by dissolving solid NaCl in 100 ml of distilled water. The sulphuric acid solution was utilized as representation of an acidic environment. The H_2SO_4 solution was prepared by adding H_2SO_4 with 100 ml of distilled water. A basic environment of NaOH solution was prepared by dissolving solid NaOH in 100 ml of distilled water. Table 1 shows equivalent weight required to prepare different molarities of the solution.

Table 1: Equivalent Weight Required to Prepare Different Molarities of the Solution

Solution	Molecular Weight (g/mol)	Molarity		
		1M	2M	3M
NaCl	58.440	5.8 g	11.6 g	17.4 g
NaOH	39.997	4 g	8 g	12 g
H_2SO_4	98.079	2.5 mL	5 mL	7.5 mL

Corrosion Test

The conventional weight loss method was utilized to conduct the corrosion tests as per the ASTM standards of G1 at room temperature (28°C). Aluminium 7075 with different 0, 2, 4, 6 and 8 wt% of carbon fiber MMCs are immersed in the various molarities (1, 2 and 3M) of solutions of sodium chloride, sodium hydroxide and sulphuric acid for different durations.

So as to acquire a smooth and indistinguishable surface, the samples were cleaned with SiC emery paper of grade 450 to 650 grit size and again the samples are washed with refined water, trailed by acetone, dried completely. They were at last weighed to an exactness of three decimal place. The weighed samples were submerged in the corrosive environments as shown in Figure 2. The test samples were removed after 10 day intervals for testing to an aggregate of 50 days. A test condition was analysed on one specimen only and the eroded layers that were formed on the specimens were eliminated with an abound brush. These samples were weighed and weight loss is calculated.

Figure 2: Samples Immersed in Different Corrosive Medium

The corrosion rate is calculated by using the formula,

$$CR = \frac{W}{DAT} \times K \text{ mils penetration / year (mpy)}$$

W - Weight loss (gm)

K= 22300 (Constant)

D – Density of composites (g/cm^3)

A – Area of the specimen (inch^2)

T – Time duration (days)

RESULTS AND DISCUSSIONS

Effect of Corrosion Duration on wt% of Carbon Fiber

The specimens with casted Al7075 alloy and 2, 4, 6 and 8wt% of carbon fiber reinforced metal matrix composites were immersed in sodium chloride (NaCl), sodium hydroxide (NaOH) and sulphuric acid (H_2SO_4) solutions, exposed for time durations of 10, 20, 30, 40 and 50 days. The initial weight of the specimen was noted before immersion in solution. After subjecting to exposure of corrosive medium the specimen was cleaned. Weight loss due to corrosion of MMCs were noted and corrosion rate was calculated.

Figure 3 shows the corrosion effects of 0, 2, 4, 6 and 8wt% nickel coated carbon fiber reinforced Al7075 MMCs in different time duration with 3M of NaCl solution.

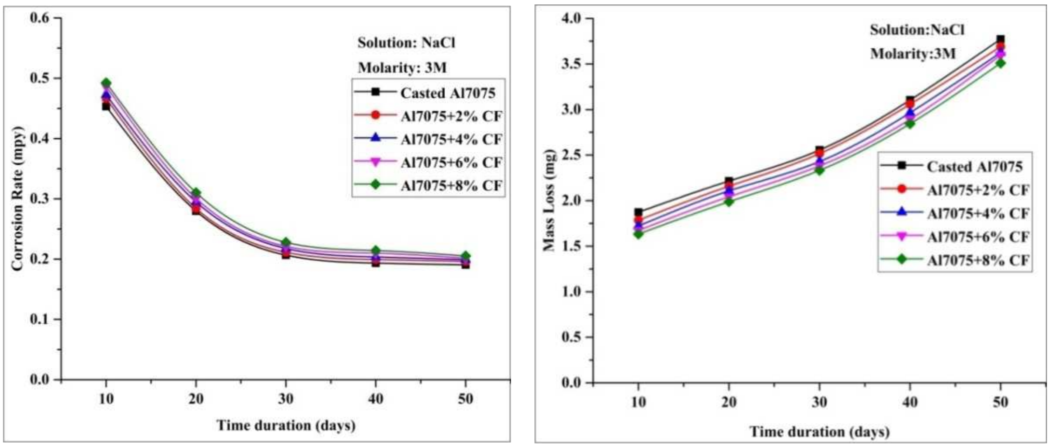

Figure 3: Variation of Corrosion Rate and Mass Loss of MMCs Against Different Time Duration in 3M NaCl

The trends obtained from the plot results showed that as the wt% of nickel coated carbon fiber reinforcement is increased, the mass loss due to corrosion of the prepared MMCs is increased in sodium chloride medium. In the case of a base alloy, the strength of the corrosion medium used induces crack formation on the surface, which eventually leads to the formation of pits, thereby causing the loss of material. The presence of cracks and pits on the base alloy surface was observed. The corrosion rate decreases as the exposure time increases; this is due to the formation of a passive film on the surface of composites.

Figure 4 shows the corrosion effects of 0, 2, 4, 6 and 8wt% nickel coated carbon fiber reinforced Al7075 MMCs in different time duration with 3M of NaOH solution.

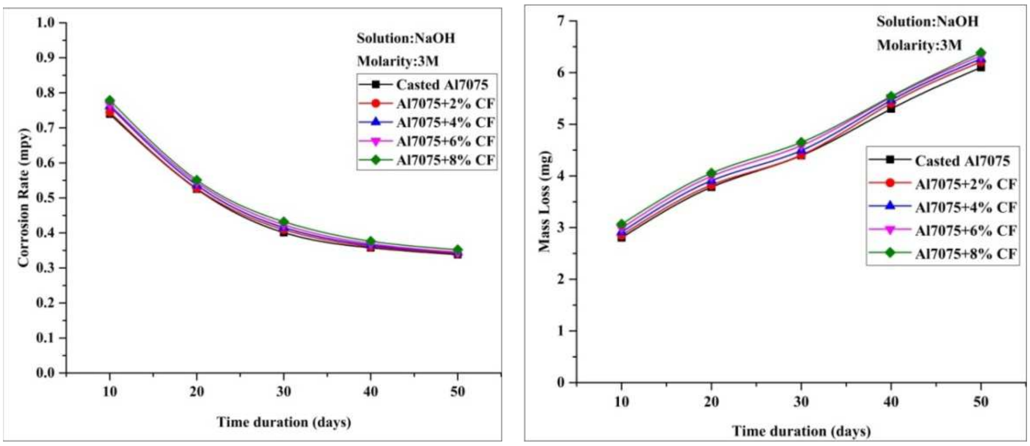

Figure 4: Variation of Corrosion Rate and Mass Loss of MMCs Against Different Time Duration in 3M NaOH

The trends obtained from the plot results showed that as the wt% of nickel coated carbon fiber reinforcement is increased, the mass loss due to corrosion of the prepared MMCs is increased in sodium hydroxide medium. The corrosion of aluminium in different molarities NaOH solution is inhibited by the addition of some mono azo dyes compounds. The inhibition efficiency increases with an increase in the concentration of these compounds but decreases with an increase in temperature. The inhibitive effect of these compounds is attributed to the formation of insoluble complex adsorbed on the metal surface.

Figure 5 shows the corrosion effects of 0, 2, 4, 6 and 8wt% nickel coated carbon fiber reinforced Al7075 MMCs in different time durations with 3M of H_2SO_4 solution.

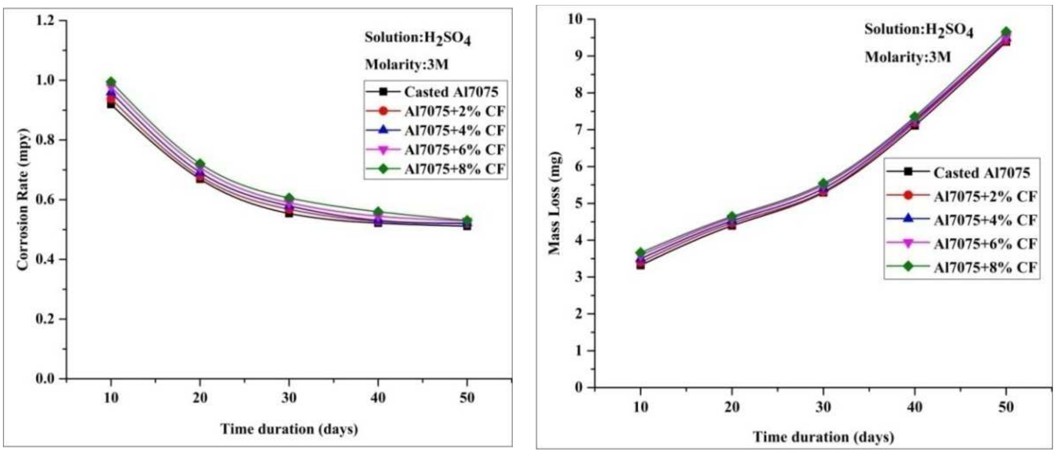

Figure 5: Variation of Corrosion Rate and Mass Loss of MMCs Against Different Time Duration in 3M H_2SO_4

The trends obtained from the plot results showed that as the percentage of nickel coated carbon fiber reinforcement is increased, the mass loss due to corrosion of the prepared MMCs is increased in the sulphuric acid medium. Initially, corrosion rate high, as the time exposure increases the rate of corrosion is decreases due to the formation of a passive film on the surface of composites. The protective black film consists of hydrogen hydroxyl chloride film, which retards the forward reaction, the black film consists of aluminium hydroxide compound this layer protects further

corrosion in acid media.

Variation of Corrosion Rate in Different Corrosive Medium

Figures 6 (a) and (b) show the variation of corrosion rate against different time duration for casted Al7075 and 8wt% carbon fiber in NaCl, NaOH and H_2SO_4 solutions.

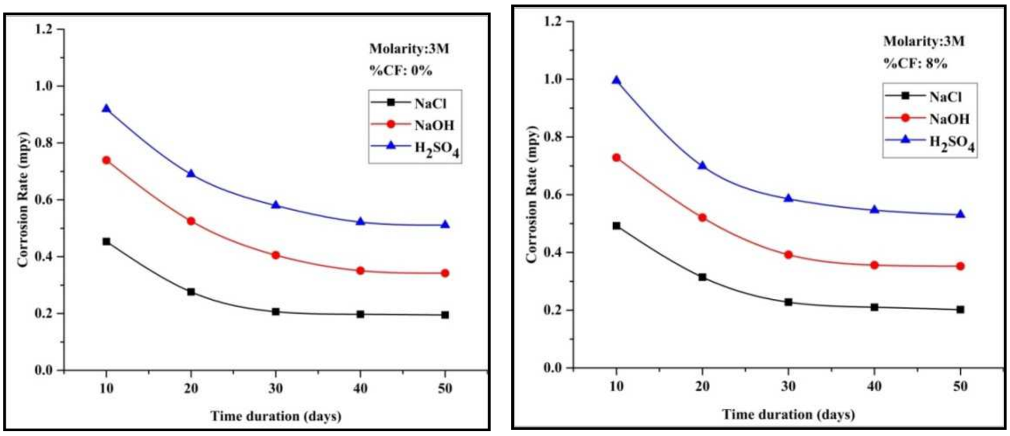

Figure 6: Variation of Corrosion Behaviour of Casted Al7075 Alloy and 8% CF Reinforced MMCs in Different Corrosive Medium

From the plots, it has been observed that the corrosion loss is high in the medium of H_2SO_4 compared to other mediums. Sulphuric acid is a stronger acidic solution hence it causes higher corrosion loss compared to other two mediums. Sodium hydroxide is a stronger basic solution and the presence of hydroxyl ions enhances corrosion reaction quietly more compared to sodium chloride solution.

Variation of Corrosion Rate in Different Molarity of Solution

Figures 7 (a), (b) and (c) show the variation of corrosion rate versus different time duration for casted Al7075 and 8wt% carbon fiber in various molarity of solutions of NaCl, NaOH and H_2SO_4

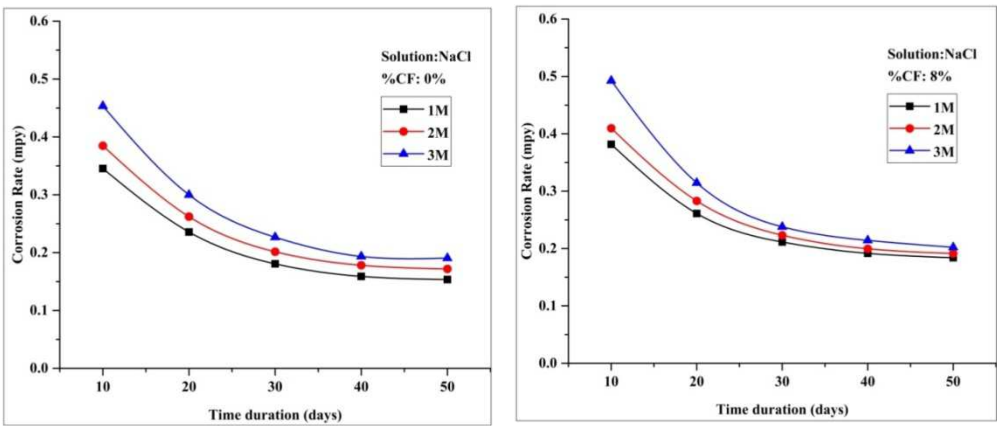

Figure 7 (a): Variation of Corrosion Behaviour of Casted Al7075 Alloy and 8% CF Reinforced MMCs at Different Molarities

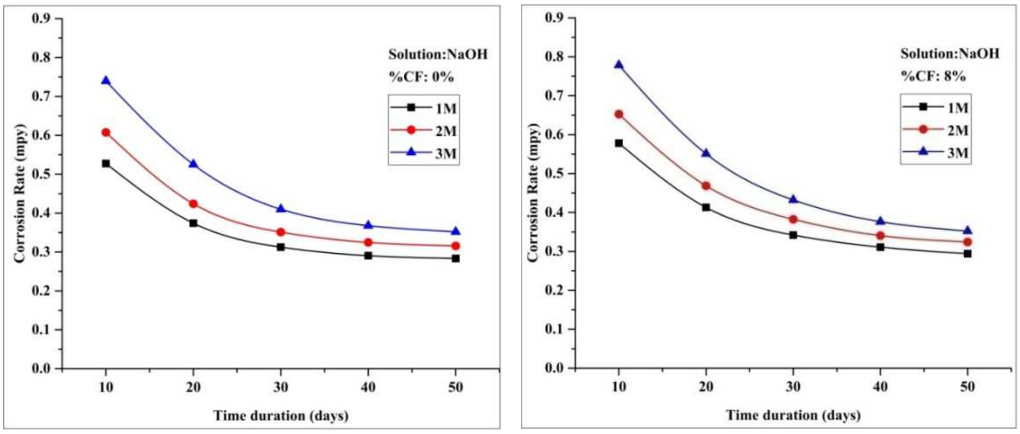

Figure 7 (b): Variation of Corrosion Behaviour of Casted Al7075 Alloy and 8% CF Reinforced MMCs at Different Molarities

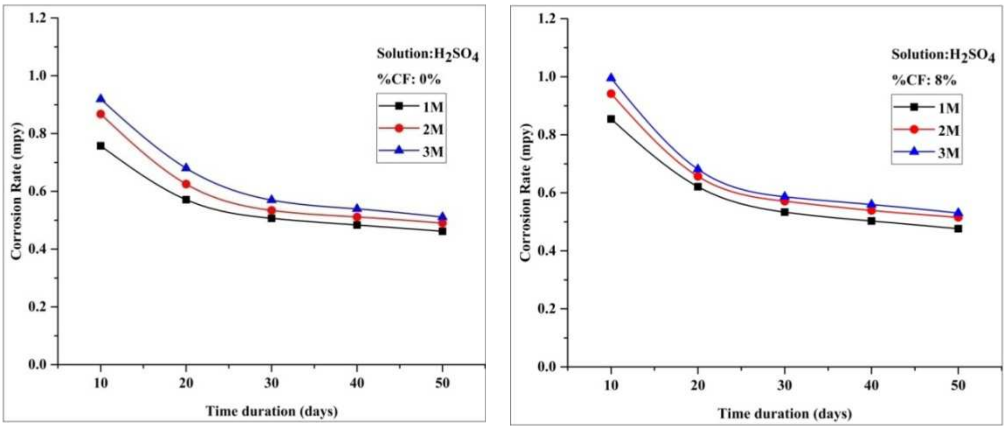

Figure 7 (c): Variation of Corrosion Behaviour of Casted Al7075 Alloy and 8% CF Reinforced MMCs at Different Molarities

From the plot results, it can be observed that as the molarity of the corrosive medium increases the corrosion rate is increased.

Studies on Corroded Surfaces

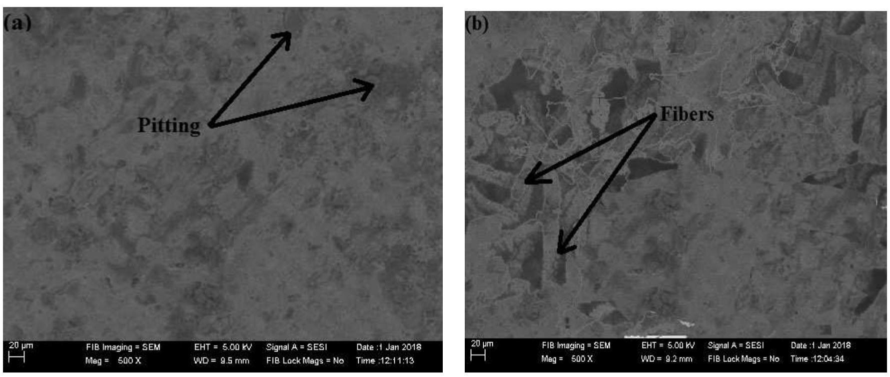

Figure 8: SEM of Corroded Surfaces of cast Al7075 Reinforced with (a) Casted Al7075 Alloy and (b) 8wt% CF

The corroded surfaces were observed in scanning electron microscope (SEM). Figure 8 shows corroded surface of a) as cast aluminium and b) 8 wt% of carbon fiber exposed for 50 days in sodium chloride (NaCl) solution of 3 molarity. Figure 8 (a) shows the SEM image of unreinforced matrix alloy, revealing the presence of cracks on the surface. Along the

boundary of the surface of an unreinforced matrix alloy, it experiences an extreme degradation. In case 8 wt% of carbon fibers showed round pits distributed all over the surface, intense generalized attacks of pits were not found near the matrix as shown in Figure 8 (b). Therefore, the pitting occurs preferentially in correspondence with carbon short fiber clusters. It gave rise to a few wide pits, which were distributed on the surface of the specimen.

CONCLUSIONS

The corrosion rate is found to be increasing as the weight percentage of the short carbon fiber increases in the composites, owing to the density of interfaces. Generally, interfaces have lower corrosion resistance.

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